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Plas'O'Soins: A software platform for modeling, planning and monitoring homecare activities

R. Bastide^{a,*}, P. Bardy^b, B. Borrel^c, C. Boszodi^d, M. Bouet^e, K. Gani^e, E. Gayraud^f,
D. Gourc^g, E. Lamine^a, P.-H. Manenq^h, M. Schneider^e, F. Toumani^e

^a ISIS-IRIT, Université de Toulouse, Campus Universitaire, rue Firmin-Oulès, 81104 Castres, France

^b UMT, 202, avenue Pélissier, 81100 Albi, France

^c Centre hospitalier d'Albi, 81000 Albi, France

^d CARMI, 2, avenue Bouloc-Torcatis, 81400 Carmaux, France

^e LIMOS, Université Clermont-Ferrand II, campus des Cézeaux, 63173 Aubière, France

^f CGX SYSTEM, Le Causse, 81100 Castres, France

^g CGI-EMAC, route de Teillet, 81013 Albi, France

^h Alмеры, 5, avenue Marcel-Dassault, 31500 Toulouse, France

Abstract

Demographic changes in recent years have contributed to a shift in care models, with the development of homecare as a new alternative to traditional hospitalization. We present a software platform dedicated to the modeling, planning and monitoring of homecare workflows, developed in the framework of the French research program TecSan. The platform is used on the desktop by care coordinators, and on the go by care workers using mobile devices.

1. Introduction

France now counts 14 million people over age 60, so 21% of the population. People over 75 represent 8.6% of the population. According to estimates, their number will almost double in the next 10 years. Increased life expectancy leads to a more than proportional increase of the 'fragile' persons. Direct consequence of this finding is the increased cost of care and hospitalization. These demographic changes, with a rapid ageing of the population and a growing segment of people with chronic illnesses and physical disabilities, in addition to the increasing costs in the healthcare sector, are having a growing and profound impact on the health care system [1]. These changes lead to a need for new care delivery mechanisms and structures [2].

Out of that, in many countries have come different alternatives. One of these new initiatives is the homecare. In recent years we are noting an increasing demand for homecare

services: in France, as it is mentioned in [3], between 2005 and 2009 the number of persons under homecare increased by 120%, the number of hospitalization days in homecare raised by 119% and the number of patients increased 148%. In Canada too, homecare organizations are growing rapidly. It is even the most rapidly expanding sector of the Canadian health care delivery system [4].

Finding ways to deliver high quality health care adapted to the needs of these patients is a major challenge for health care system. In response to this challenge, there is a considerable international interest in exploiting the Information and Communication Technologies (ICT) solutions to enhance the quality and safety of health care in general and homecare in particular.

These trends are strong incentives for e-Health research. The European Union has undertaken a number of research projects to assist the elderly, proposing solutions to the issues of mobility (I2HOME), communication (SHARE-it), remote monitoring (CAALYX, eCAALYX), timely access to patient specific information (COGKNOW, EasyLine+), and involving patients more actively in their own care process (Coplinfo).

* Corresponding author.

E-mail addresses: Remi.Bastide@irit.fr, Remi.Bastide@gmail.com (R. Bastide).

1.1. The French homecare ecosystem

In France, homecare is mainly managed by regional associations, which coordinate the activity of all the persons involved (doctors, nurses, house cleaning, meal delivery, etc.).

The stakeholders in the homecare process widely differ in terms of their organizational structure, responsibility and technical ability:

- most of the medical staff involved in homecare in France (doctors, nurses) are self-employed (liberal profession): they have no hierarchic dependency on the organization that manages the overall homecare process. They usually possess their own information system support (albeit very limited): agenda management, paper or digital patient records, etc.;
- on the other hand, house cleaning and meal delivery is usually performed by staff employed by municipalities or the homecare association themselves. These people have little computer literacy, and are often reluctant to use computer-based system in their daily work;
- the elderly's relative often live far away from their elderly parent, paying him irregular visits. However, they wish to keep in touch with their parent using phone, and to be kept informed on his health state;
- finally, the homecare system is funded by regional public units, which are billed for the work of the various stakeholders. These units need to be reliably informed of the actual work that has been performed, time spent at home by the various stakeholders, etc.

Currently, the activity of all these persons is managed largely manually, using a so-called 'liaison logbook', a physical notebook kept at the elderly's home, which is read from and written to by all the persons that intervene in the patient's care, including the patient's relatives. The liaison logbook is generally an unstructured, physical notebook that is kept at the elderly's home. It is used for communication between the family and the various stakeholders. Each stakeholder notes the date of the visit, the operations performed, recommendations or any other form of comment.

It is noteworthy that the liaison logbook contains very useful data, underused in the homecare process. Indeed, it stores information of different types: logistical information which helps for the coordination of activities, medical information, general information on the patient, any information which may help improve the quality of the homecare and possibly the detection of the patient health change via an intelligent monitoring system.

This mode of communication has several limits:

- a communication that is not always clear and reliable: the stakeholders must scan through the liaison logbook for information which is intended to them, or for which they are likely to be interested. As long as the liaison logbook remains at the patient's home, the stakeholders must not forget to read it and must be able to accurately transcribe its information;
- lack of privacy and security: because the liaison logbook is at home of the dependent person, each party may have access

to all information written on the logbook. It can be easily polluted with wrong information, either inadvertently or by malicious people.

1.2. Processes in homecare

The activity of homecare gives rise to communication and coordination problems. To ensure the coordination and continuity of care, and to improve its quality, the caregivers involved on homecare are mandated to:

- ensure the accuracy of information, by automating the transmission of information and by avoiding several transcriptions for the same information;
- guarantee the timely transmission of information to the appropriate stakeholders, be it information about the patient's condition or other logistical information;
- ensure the transmission of information about the actual medical or paramedical interventions performed by the caregivers;
- ensure the storage of information about the evolution of patient's health conditions.

1.3. Homecare processes

In the literature, there are many research works about homecare processes and particularly on medical homecare. In [3], the "National federation of institutions hospitalization at home" (FNEHAD) provides a mapping process for patients under medical homecare, considering that computer support is still underdeveloped in institutions of medical homecare. This work aims to structure information systems for homecare and stands as a reference in this area, as it encompasses all processes presented in other works. Fig. 1 shows the main processes involved in homecare, following ISO 9000 that classifies processes into three types: management, operational (management of patient) and support (Human resources, purchasing and logistics. . .).

The Plas'O'Soins platform is mainly concerned with the "delivery of care" and "coordination and monitoring of care" processes, while being interoperable with the tools that support the other processes, such as "billing" or "human resources".

1.4. Workflow in homecare

To cope with the drawbacks addressed above, we suggest the automation of some processes of patient management.

We distinguish two sets of processes: the first set includes the "admission request", "preadmission", "billing stays" and "discharge" processes, which are prone to be automated by a classical workflow management system. The second set of processes includes "delivery of care" and "coordination and monitoring of care" that are the main topic of the present paper. The characteristics of these processes make the design of workflows for their automation a difficult task.

This set of processes has the following characteristics:

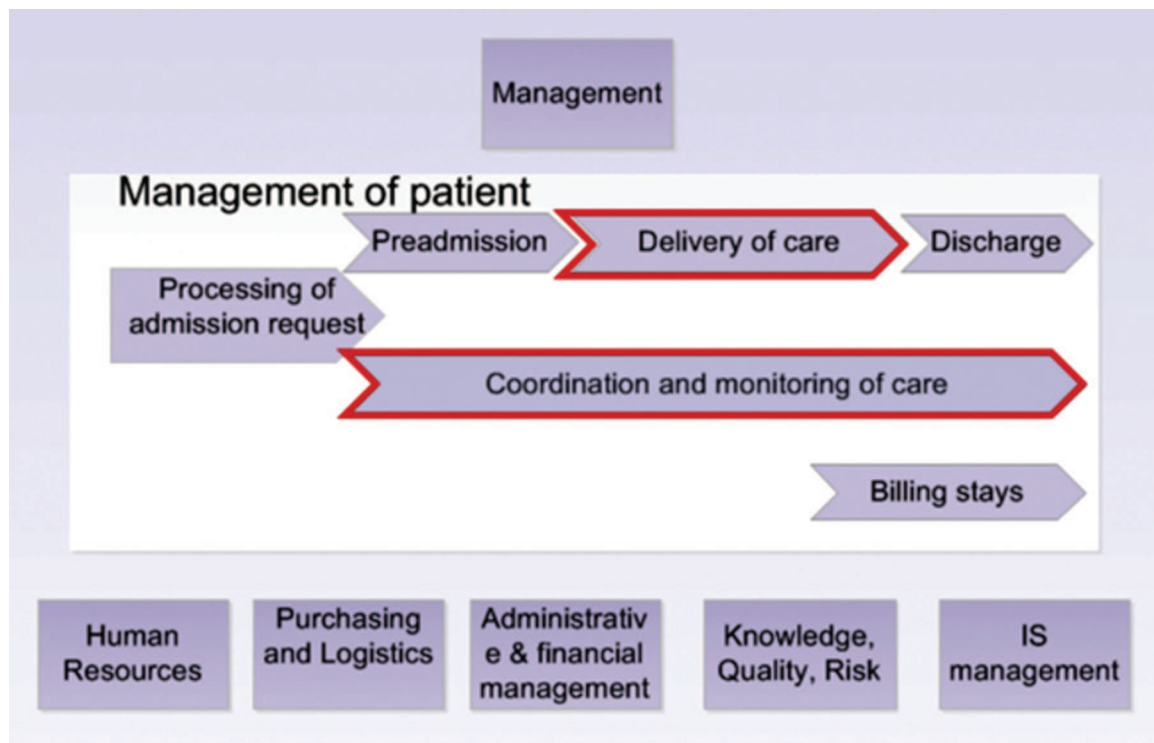


Fig. 1. Main processes of homecare.

- it usually extends over long periods of time, especially in the case of chronic illness;
- it requires the coordination of numerous and different stakeholders;
- it is non-routine, each patient being a specific case due to particular health conditions, social networking, geographic location, etc.;
- it represents a collaborative process, deployed in a dynamically evolving setting. The homecare processes present a strong human component, distributed among several actors with various levels of autonomy;
- it evolves dynamically, according to the changing health of the patient and his environment. In general, the process it required to quickly and easily adapt to a changing environment;
- it presents a temporal complexity, as the tasks in homecare have complex frequency and duration constraints that are inconvenient to represent in conventional workflow models.

This organizational complexity formed the rationale for the Plas'O'Soins project, described in this paper. The goal of the project is to develop a technological platform allowing for the orchestration of homecare processes, with the aim to improve this type of care and to face unforeseen events. This platform is meant to answer the needs of homecare or home hospitalization structures, in terms of coordination, planning and monitoring of the care plans, and of the stakeholders' activities.

The Plas'O'Soins platform provides for:

- the rendering of real-time state of the care process, either globally or on a per-actor basis;

- the timely transmission of information (alerts, schedule changes. . .) towards the appropriate stakeholder;
- the planning and coordination of activities, and their dynamic re-planning;
- the managing of coherence and traceability of activities;
- the help to the decision process by providing statistic data.

Plas'O'Soins deals with the coordination of activities in home health care, activity tracing and monitoring. The project will provide a platform supporting the definition and agile monitoring of personalized care processes, helping to coordinate and plan activities, while helping the communication between actors, and providing efficiency indicators.

2. Material/Patients

The Plas'O'Soins platform is designed to be used mainly by the medical and paramedical staff involved in homecare. The patients' use of the platform mainly consists in consulting their weekly planning, and being informed of relevant information, such as the re-scheduling of a planned nurse visit.

The main actors/use cases of the platform are as follows:

- homecare coordinator: usually a nurse, employed by the homecare association. Her main use cases consist in:
 - defining the patients' care plans, and updating them according to the evolution of the patient's health state,
 - define organizational constraints that are influential to the scheduling results, such as working our and periodic staff leaves,

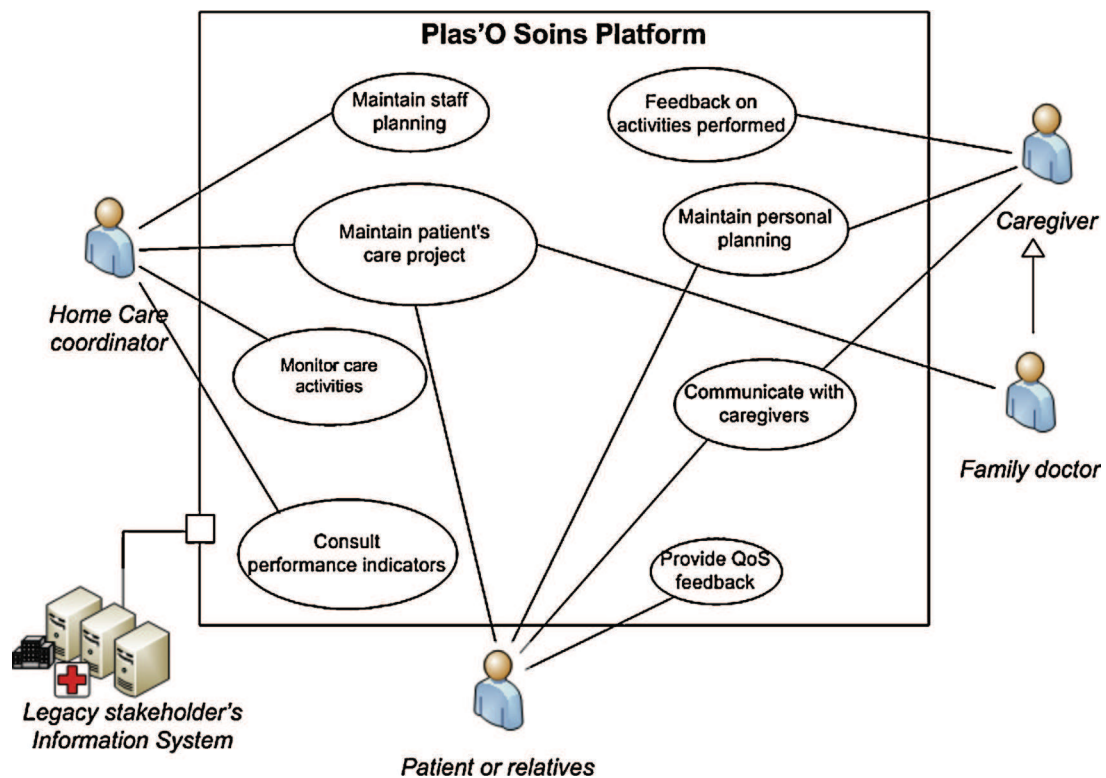


Fig. 2. Use cases of the Plas'O'Soins platform.

- monitor the execution of homecare acts: from the real-time information provided by caregivers, the coordinator can be informed about delays in the performance of acts;
- caregivers (nurses, medical aids. . .) use the platform “on the go” through smartphones or other mobile devices:
 - they can access their schedule planning, with the detail of the patients they need to visit and the medical acts to perform at each patient’s,
 - as they provide the care, they can inform the coordinator about the performance and timeliness of the acts performed (Fig. 2).

3. Methods

Plas'O'Soins features several innovative aspects, regarding on the one hand the inter-organizational coordination between stakeholders, presenting a wide variety in information system support. On the other hand the system tackles the dynamism of activities, resulting from the mobility of actors, and from the need for personalization of care processes. Plas'O'Soins tackles the constraints stemming from the sensitive nature of the information, and deal with usability and social acceptability concerns.

The main scientific aspects included in the project are:

- the definition of a Domain Specific Language (DSL) for homecare processes, targeted to end-user programming;
- the definition of an agile mediation architecture based on web services, allowing for the agile execution and monitoring of the processes defined by the DSL;

- the definition of a process for activity continuity, that allows ensuring the continuing providing of care even under technical and organizational failure.

4. Results

4.1. A domain specific language for care processes

After a thorough domain analysis performed with end-users we defined a Domain Specific Language (DSL) for specifying care plans. This DSL allows for specifying planned actions, interventions and three visions of the care plan (forecast, planned, executed).

A care plan is expressed as set of medical and paramedical *acts* (e.g. injection, or toilet), each associated with temporal modalities. Several acts can be combined into a single *intervention* if they require the same medical expertise, and if their temporal modalities are compatible. The expression of temporality for acts and interventions, which is an integral part of the DSL, has been the subject of a specific study that led to the proposal of a specification language for almost periodic recurrences.

The objective is to provide a language for expressing repetitions for acts or interventions over time in a condensed form, similar to the form used by physicians to their requirements (e.g. “daily and nightly for 3 days and then daily for 5 days”). A condensed form is preferred because it is more compact to communicate than a developed form such as an agenda with the list of occurrences of the activity. In addition the DSL must be able to handle irregularities.

Table 1
Examples of temporal expressions.

Period	Days	Intervals
Apr. 21, 2013–May 5, 2013	Monday, Wednesday, Friday	Morning, evening
Period	Days	Intervals
Apr. 21, 2013–May 15, 2013	Every day	Morning

Table 2
Non-overlapping temporal expressions.

Period	Days	Intervals
Apr. 21, 2013–May 15, 2013	Monday, Wednesday, Friday	Morning, evening
Apr. 21, 2013–May 15, 2013	Sunday	Morning

This section introduces the DSL in a intuitive manner consistent with a user-centered vision. A more formal presentation is available in [5].

Temporality for acts is specified via a triplet (period, day, intervals). It is used to express a simple regular repetition as shown in the two examples below (Table 1).

Days and intervals can take different forms to accommodate various possibilities encountered in the medical world. Days can be a list of weekdays, or a list of dates, or an expression (Every day, Every odd day. . .). Intervals may specify daily time-frames (morning, evening. . .) time slots (10 a.m.–11 a.m.) or a specific time (10 a.m.). All these values are combined, provided that the corresponding time slots do not overlap.

However, a repetition of acts is not always entirely consistent. In addition there may be exceptions. Our language allows combining several specifications of temporality to express a superposition of patterns or exceptions.

This combination is not a problem as long as the days associated with various expressions are pairwise disjoint as in the following example (Table 2).

However, a problem arises when the days associated with different expressions are not disjoint as shown below. In the following example, there is ambiguity because we do not know if Sunday activity must take place in the morning and in the evening or in the morning only (Table 3).

To resolve this ambiguity, we introduce the notion of overload: a statement overloads all those preceding it. So in the above example the second term is the first priority for every Sunday.

With this notion of overload it is easy to express complex repetitions or exceptions, by inserting as many expressions as needed and ranking them properly. In the example below, the

Table 3
Overlapping temporal expressions.

Period	Days	Intervals
Apr. 21, 2013–May 15, 2013	Every day	Morning, evening
Apr. 21, 2013–May 5, 2013	Sunday	Morning

Table 4
Overloaded temporal expressions.

Period	Days	Intervals
Apr. 21, 2013–May 15, 2013	Every day	Morning, evening
Apr. 21, 2013–May 15, 2013	Sunday	Morning
Apr. 21, 2013–May 15, 2013	Holiday	None

activity occurs every morning and evening (general), except on Sundays when it occurs only in the morning (specificity). In case of holiday, the activity is not maintained (other specificity) (Table 4).

From the condensed representation, we can produce an expanded form suitable for an agenda by processing each line, starting from the last one.

4.2. Planning strategies

The concept of intervention is used to describe a visit at the patient's home, undertaken by a medical or paramedical staff on a specified time slot. There may be one or several technical acts performed by the staff on a single visit. This combination of acts may be required and scheduled by the coordinator for technical reasons, and/or proposed by the care plan editor software. Interventions are composed of a specific identifier, the patient involved, the specified time of care, the day scheduled for the intervention and the desired time range.

A software module is dedicated to calculate a feasible planning of all the required interventions, taking into account the availability of medical or paramedical staff [6]. The planning module also considers the geo-localization of patients, in order to minimize the driving distance required to visit all the patients daily. The planning modules has the responsibility to organize all planned interventions into *shifts*, i.e. a series of interventions that can be performed by a single staff member in a single day, taking into account the working hours and the driving distance involved.

The number of shifts per day and their amplitude are required in order to build the schedules. Every possible shift is characterized by the start time and end time to comply with, the type of feasible interventions depending on the worker assigned to the shift.

Planning has to determine a start time for each intervention considered, and to insert it into a shift. The planning algorithm aims to optimize, while respecting certain constraints, the travel time between patients for all acts to be performed on one day.

The planning module uses a variant of the tabu search algorithm [7] to constructs a set of solutions that meet the constraints set. These solutions are visually presented to the user, who can select the preferred solution. It may happen that no solution can be provided that complies with the constraint. This situation is not exceptional, and in this case the coordinator has the opportunity to hire new self-employed nurses, and thus relax the constraints on the available work force.

To evaluate the solutions provided by the planning module, we have defined several criteria to compare and seek the best

solutions. These criteria were developed based on discussions with end-users.

- time windows, this criterion ensures that the planned interventions in this solution are well planned in accordance with the desired time slots. A value of zero indicates that all operations comply with the constraints, while a positive value indicates the total amount of overflows in interventions;
- duration of the shift;
- time between interventions: In the case of multiple visits to the same patient during a single day, it is requested that a minimum period (e.g. 3 hours) is observed between each visit so as to spread over the whole day.

5. Discussion

The constraint-based planning approach presents a potential flaw: it is quite common that all relevant constraints are not formally expressed, either because the software does not allow for it, or because the coordinator would be reluctant to express constraints of intimate nature (such as, for instance, the fact that there are personal conflicts between a nurse and a patient). As a result, the results of the scheduling algorithm may prove unsatisfactory.

To alleviate for this constraint, we allow the coordinator to choose from the solutions provided by the algorithm, and to manually adjust schedules, as long as the initial constraints are met. The scheduling for the past week is also fed as an input to the algorithm, which will favor solutions with minimal disruptions from previous schedules. We believe that this strategy will produce satisfactory schedules, even though all constraints are not formally expressed.

The caregivers access the Plas'O'Soins platform on the go, through mobile devices such as smartphones or tablets. Currently, the care staff has little computer literacy, and is not accustomed to the use of mobile devices. With the end-users partners in the Plas'O'Soins consortium, we have run experiments of the mobile user interface with the care staff, in realistic situations. Several problems have been pointed out, some resulting from lack of practice with mobile devices, and others resulting

from technical and ethical questioning from the staff, such as the fear of being continuously tracked by the system during their working shift. These usability concerns need to be tackled, and a change leading strategy has to be defined to ensure a smooth integration of this new technology within the current practices and habits of homecare.

6. Conclusion

The work presented here has been developed in the framework of project Plas'O'Soins, a nationwide project funded by the French National Agency for Research (ANR), within the Tec-San framework and is also supported by the Cancer Bio Santé cluster.

The Plas'O'Soins consortium includes academics, ICT industries and end-users. Associated partners contribute to project management, ethics and law concerns and also represent the agencies that fund home health care in France.

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